

TRANSMISSION DESIGN CONSIDERATIONS
FOR SERVING AREA VALUE ENGINEERING

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1. GENERAL

1.1 This section provides REA borrowers, consulting engineers and other interested parties with recommendations on the application of electronic equipment to REA's Serving Area Value Engineering Guidelines for the design of rural telephone plant. This is a companion section to REA's TE&CM 230, General Principles for Serving Area Value Engineering, and TE&CM 231, Design Techniques for Serving Area Value Engineering. Increased emphasis is placed on the use of pair gain devices such as distributed and grouped station carrier, PCM carrier and electronic concentrators. Subscriber line radio, common mode operation and voice frequency repeaters with automatic gain control (AGC) are also emphasized.

1.2 Multi-channel station carrier provides up to seven channels over a single pair of wires. It can be procured with individual channel housings or a grouped channel housing for use in the field. Station carrier should be considered as a means to provide feeder circuits without physical reinforcement of existing plant, especially on small size facilities.

1.3 PCM subscriber carrier provides 24 or 36 subscriber circuits over a PCM span line. Although it can be applied to existing plant, its use will be primarily on new cable plant. This equipment provides a large number of feeder circuits to a serving area interface (SAI).

1.4 Systems which employ switching at a location remote from the central office can also be used to provide pair gain to an SAI. These systems, employing either PCM or physical circuits for the link to the office, can provide around 100 lines over 24 trunks or 24 lines over 6 trunks. Such systems may be used effectively in locations where future offices are planned as well as where existing offices are being phased out.

1.5 Radio is analogous to wire plant. Instead of applying carrier to wire plant it is transmitted over radio. Of particular interest to the new system design is that carrier over radio could be used for feeder circuits to a remote SAI. PCM carrier and PCM carrier concentrators are the type of equipment most likely to be employed in conjunction with radio.

2. VOICE FREQUENCY EQUIPMENT

2.1 Design of physical subscriber circuits should follow the procedure and guidelines outlined in Telephone Engineering and Construction Manual, Sections 415 and 424. The design limit is 8 dB at 1000 Hz. Application of the Serving Area Value Engineering Guidelines will not affect the transmission design of physical circuits except in the following instances.

2.11 The subscriber end section of a D-66 loaded line may range from 0 to 9 kilofeet. Subscriber end section of an H-88 loaded line may range from 0 to 6 kilofeet. These limits are designed to facilitate the transition to carrier feeders at an SAI at a later date. The shorter end sections offset the added loss when the near-end sections facing the carrier at an SAI are longer than one-half load section. Traditionally, a loaded voice frequency extension off of a carrier channel would have the first load coil at a point one-half section from the carrier. This is sacrificed in this design concept to enable placement of the SAIs at the most desirable physical location. Refer to Exhibit I.

2.12 An SAI can be located at any physical point at or between two load points. No special near-end section considerations are necessary except in situations where voice frequency gain may be required due to loop length beyond the SAI. Such conditions will usually be encountered when concentrators are used with carrier derived trunks and the voice extensions are so long as to require voice frequency repeaters.

2.121 When the loaded cable near-end section of distribution pairs is 0.4 load section (1.8kf D-66 and 2.4kf H-88) and longer in length, no special treatment is required. Line build-out network of the voice frequency repeater should be set for best return loss performance. If the end section is .8 to 1 full section, the return loss is slightly degraded but the performance is still acceptable.

2.122 Loaded cable near-end sections of distribution pairs shorter than 0.4 load section should be built out to one-half of a full load section by installing a capacitor of correct value at the location of the first loading coil beyond the SAI.

2.13 The design will generally provide for the use of carrier in serving subscribers at long distances from the central office. The use of field mounted voice frequency repeaters is discouraged because long subscriber loops are subjected to noise induction from power lines. They should only be used where there would be an insufficient amount of subscriber carrier to warrant the introduction of carrier.

2.14 Under this design strategy, it will be necessary to calculate the loss of a length of loaded line where the near-end section is not the ideal half load section. The near-end section may be considered a half load section when the physical length is shorter than the half section. The capacitor build-out provides the proper half section performance. When the physical near-end section is longer than a half load section, that length exceeding a half section in both the near and far-end section have losses equal to the same length of the nonloaded cable. This loss is added to the normal loaded loss of the remaining cable to arrive at the total loop loss. As an example, if a 24 gauge D-66 loop originating out from a PCM terminal begins with a full section, has three load coils and a far-end section of 4.5 kilofeet, the equivalent length of nonloaded cable is $2250 + (4500 - 2250) = 4500$ feet. This length of nonloaded cable has a loss of 1.98 dB. The loss of the remaining 13.5 kilofeet of loaded cable is 3.1 dB for a total loss of 5.08 dB.

2.2 The use of 24-gauge cable is recommended for most applications as a means of reducing costs. For loops longer than 15 miles, 22-gauge cable may be used and 19-gauge cable may be used for loops that extend 25 miles. The use of 26-gauge should only be considered for cables that are all feeders (no distribution), 200 pair or larger, not to be used for carrier at any point in the future and where no loop exceeds 15 kilofeet.

2.3 In conjunction with the use of fine gauge cable, the application of low cost electronic equipment, voice frequency repeaters and loop extenders, will effectively extend the range beyond the point which can be served with the next larger cable gauge without electronics.

2.31 Where the number of physical loops exceeding 1700 ohms of outside plant is sufficiently large, consideration should be given to Common Mode Operation of voice frequency repeater and loop extender equipment. This provides significant costs savings by serving a number of subscribers with a smaller amount of electronic equipment. Reliability is also enhanced because a repeater failure does not necessarily remove a subscriber from service.

2.32 In Common Mode Operation, utilizing a voice frequency repeater with automatic gain control will reduce the costs generated by the need for transmission zoning when fixed gain repeaters are used.

3. STATION CARRIER

3.1 Distributed Station Carrier

3.11 Field of Use: Distributed station carrier serves a unique purpose in this design concept. Its use may often avoid reinforcement of small size cables and extend the life of existing plant. Low subscriber density and slow growth increase the probability that distributed station carrier will be the most economical method of reinforcement. Presently, up to seven one-party subscribers can be served on one cable pair using station carrier.

3.12 Multi-channel distributed station carrier should be considered as an economical alternative to adding cable pairs. The carrier subscriber terminal is located near the subscriber it serves, eliminating the need for distribution pairs. Distributed station carrier can be used with physical loops and PCM carrier in the same cable to arrive at the most economical and practical means of providing service.

3.2 Grouped Station Carrier

3.21 Grouped station carrier consists of the same electronic equipment as the distributed type except that the field mounted subscriber terminals are packaged in groups of complete systems. This results in substantial initial savings of as much as \$100 per channel over the distributed type because of the savings in individual housings and power supplies for each channel. This type of station carrier can be applied at SAIs to provide feeder pairs to a serving area. At the SAI, the carrier is cross-connected to distribution pairs. Grouped station carrier is well suited for the new system design.

3.22 All station carrier manufacturers can now provide the grouped packaging. The voice frequency drop limits of the available equipment vary from 250 to 400 ohms. These limits must be observed on the distribution pairs from the SAI. For example, with 24-gauge D-66 loading "Design Areas" two load sections are combined into one serving area and the grouped subscriber carrier is at the SAI point, the voice drop limits of carrier equipment are exceeded. The inequalities in drop limits among the various manufacturers must be considered to select the proper equipment. Refer to Exhibit I.

3.3 Station Carrier Application

3.31 Repeatered Line: The station carrier repeatered line should be engineered as prescribed in TE&CM 911:

- a. Establish the repeater points very near the computed 35 dB point (at 112 Hz). An SAI or PCM repeater point should be chosen for the repeater if between 32 and 36 dB.

- b. If the loop resistance of the carrier line exceeds the system limitations (usually about 2600-3000 ohms), insert power at a convenient field location within the powering limitation. For economic reasons, choose a field location common to most or all systems requiring field power.
- c. Existing cables of 22 and 19-gauge should be considered for station carrier because of the greater distance range. An examination of the electrical characteristics of these cables must be made to insure that they really can be used for station carrier. This requires field measurements.

3.32 Subscriber Terminals: The subscriber terminals are designed so that one or more terminals may be placed individually or in groups within 35 dB of a repeater along the route (or the central office terminal). For distributed station carrier, the subscriber terminals can be placed inside SAI or cable pedestal housings. This may require replacing small cable pedestals with a larger type pedestal. The subscriber terminal should be placed in the pedestal nearest to the subscriber to be served by that carrier channel; however, it may be placed some distance back along the repeated line within the limits stated for the voice drop. For grouped station carrier, the equipment should be housed in the cabinets furnished by the supplier for one or two groups. Larger type cabinets can also be procured from the supplier for large installations, 50-100 channels. This cabinet can be pad or pole mounted next to an SAI housing to which it is interconnected by means of a cable stub. If there is room, the grouped carrier could be placed inside the same housing as the SAI.

3.4 Options: The single party bridged ringing station carrier is generally the most economical. Many manufacturers can also provide the multi-party type ringing option. Other options available can also provide for key systems, PABX and some form of pay station application.

3.5 In determining the breakeven point for the economical application of carrier and the development of costs for the decision charts of TE&CM 231, it is necessary to estimate the cost of the equipment. Appendix "A" illustrates how broad gauge costs for carrier are developed.

3.6 One Channel Carrier: The one channel add-on type of station carrier is a special use carrier. The field of use is within 18 kilofeet of the office, the limit for nonloaded loops. The subscriber terminals may be mounted indoors or out-of-doors to double the number of circuits to one building or several buildings in a small area. Another application of this carrier is to utilize groups of 10 or more units at an SAI to double the effective number of feeders. The distribution would be handled over normal distribution cables, not to exceed 250 ohms from the interface.

4. PCM SUBSCRIBER CARRIER

4.1 PCM subscriber carrier systems are available that can provide 24 or 36 subscriber circuits using digital techniques employing Pulse Code Modulation. While the actual transmission of PCM carrier can be done over 2 pairs of wire, more pairs are usually required for backup and diagnostic purposes. The characteristics of this equipment are covered in TE&CM 950. The subscriber terminal is placed at an SAI where cross-connection is made to distribution pairs. The feeder circuits back to the central office are via a T1 repeatered span line.

4.2 Compartment type grease filled 24-gauge cable designed for PCM carrier can provide 100 percent pair usage for span line operation. If many systems of PCM prove economical, either initially or in the future, this type cable should be specified. Compartment type cable and its application to the PCM carrier is covered in TE&CM 950.

4.3 PCM Carrier Application

4.31 Subscriber terminals are installed at SAI points.

4.32 The voice drop capabilities of PCM carrier are from 1200 to 1500 ohms. The 1000 Hz net loss through the PCM carrier equipment is about 2 dB. Therefore, the voice extension over distribution pairs is limited to 6 dB at 1000 Hz.

4.33 Loading is required for distribution pairs if the 1000 Hz loss is greater than 6 dB (13kf of 24 gauge). Since the subscriber terminal may be located at any point with respect to the loading scheme, the first load coil may be any distance away instead of the usual half section. While there is a slight transmission degradation, this configuration will still provide satisfactory frequency response and impedance matching (return loss) provided that the end section requirements of paragraph 2.11 are met. Refer to Exhibit I.

4.34 The PCM span line is engineered as prescribed in TE&CM 950.

4.35 If SAI locations are established near proposed repeater points, repeaters may be placed at SAIs to reduce the number of housings required. While, in general, PCM repeaters should be spaced at 31 dB intervals (20 dB office end sections), these lengths may be shortened in cases where future intermediate systems are anticipated. This should be done in such a way as to minimize the number of repeater points in the ultimate system.

4.36 At the subscriber terminal, 117 Vac commercial power is required with a battery standby.

4.37 A spare span line should be provided between the subscriber terminal and the central office where two or three or more systems are operating.

4.38 Although a PCM carrier span line can be applied to air core cable if the electrical properties will support PCM, it is recommended generally that PCM span lines be implemented on new filled compartment type cable. It may well be that due to unpredictable growth, additional feeder circuits might be required where right-of-way restrictions or cost of adding more buried cables would be extremely costly. It might be good insurance to originally place compartment type cables to provide for PCM span lines for the future.

4.39 Appendix "A" illustrates how broad gauge costs for PCM carrier are developed.

5. CONCENTRATORS

5.1 Field of Use: Concentrators can be used to reduce feeder circuit requirements by about 4 to 1. This is done by providing switching equipment at the SAI. For each trunk (feeder), about four subscriber lines (distribution) can generally be served. Currently available concentrators provide 96 lines from 24 trunks, and 24 lines from 6 trunks. Other variations are in the design stage. Since installation of remote switching features reduces the call handling capabilities of the system, some consideration must be given to the calling habits (traffic) of the subscribers served by concentrators.

5.2 One type of concentrator (96 lines) is designed as an integral part of a PCM carrier system. Others are designed for use over either carrier or physical trunk back to the central office. A concentrator employing physical trunks is low in cost. The advantage of carrier trunks operating over radio or paired wire is that longer distance range is obtained more economically and transmission limits are easily met.

5.3 Subscriber terminals of concentrator equipment can be classified into three types, depending upon how the talking battery is provided to the subscriber. The three methods of providing talking battery are:

1. Directly from the central office battery supply.
2. From a subscriber carrier terminal.
3. From a local battery supply and talking bridge in the subscriber concentrator terminal.

5.4 Concentrator equipment is movable type equipment well suited for reinforcement of feeder routes as pair gain devices for this new system design.

5.5 Concentrator Application

5.51 Subscriber Terminals: Subscriber concentrator terminals are generally located at the SAI. The trunk circuits (feeders) may be loaded cable pairs or carrier channels.

5.52 If the trunks are physical cable pairs and talking battery is provided from the central office, the maximum overall distance from the central office to the subscriber is determined by the limits of the central office and associated voice frequency repeater and loop extension equipment. For loaded physical trunks, the concentrator may be located at any point with respect to load coil locations unless intra call is in use (see paragraph 5.54). If the combined distance to the subscriber load coil (including distance from load coil to SAI) is less than 9 kilofeet for D-66 or 6 kilofeet for H-88 loaded trunks, the distribution cables should be unloaded. For longer loops loading should be continued.

5.53 If the trunks are carrier derived and talking battery is provided from the carrier subscriber terminal, the maximum allowable distance from the concentrator terminal to the subscriber is determined by the resistance limit of the carrier subscriber terminal or the 8 dB at 1000 Hz limitation through the carrier and the voice drop. The transmission impairment incurred by placing the terminals at points other than the half load point is the same as for PCM subscriber carrier as discussed in paragraph 4.33.

5.54 Intra Calling: Some concentrators include intra calling links to improve the concentrator's traffic capability. In this equipment, a call between two subscribers served by the same concentrator does not tie up two trunks back to the central office. The actual connection between the subscribers is made within the concentrator itself. Such a call is termed an "intra call". Talking battery is provided from a terminal battery supply and talking bridge right at the subscriber concentrator terminal. If an intra call is made between two subscribers on loaded loops, transmission will be degraded if the concentrator is located at some point other than half way between load points. Therefore, if intra calling is required, the concentrator should be located half way between load points.

5.6 Special Applications: While, in general, the SAVE procedure allows location of interface points anywhere with respect to the loading scheme, there may be circumstances where the SAI should be located at the midpoint of a loading section.

5.61 If it is necessary to use voice frequency repeaters and loop extenders off a PCM carrier or concentrator terminal, there is no alternative but to place the terminal at midpoint to load coils. Otherwise the voice frequency repeaters will be unstable in their operation.

5.62 If the PCM carrier or concentrator equipment is located in an area destined to become a new central office location, the proper location for the equipment is at midpoint to load coils. Likewise, if a small central office is replaced with PCM carrier or concentrator equipment, the equipment may be installed at the central office location. Refer to Exhibit II.

5.63 Concentrators, where talking battery is provided from the subscriber terminal where the intra call feature is required, should be located at half way between load points as discussed above in paragraph 5.54.

6. RADIO

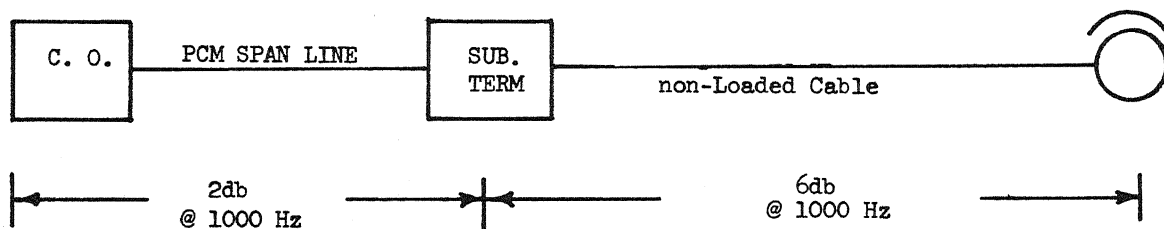
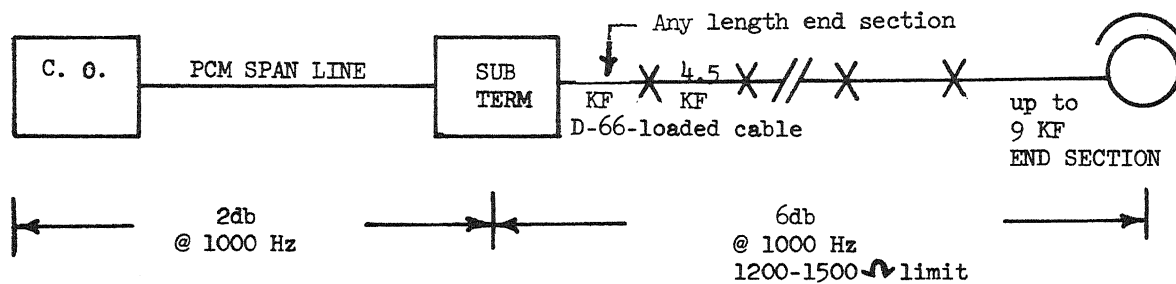
6.1 Two basic telephone transmission facilities currently available are paired wire and radio. In subscriber loop applications, wire is generally best suited for connecting stations along a route; however, radio should be considered because there are often factors that make it the better choice. Both wire and radio are capable of transmitting a single voice circuit by applying voice frequency modulation. Likewise, both are capable of transmitting many voice circuits through the application of carrier equipment. Service to a single subscriber or up to four multi-party subscribers may be provided using a single channel version called a rural subscriber radio link. Service for 100 or more lines may be provided using wide band radio (microwave) and the application of carrier. In both instances, the subscriber terminal is located at an SAI point and subscriber stations or other SAIs are connected using cable pairs out to distances of typically 400 to 1200 ohms. The carrier equipment applied to microwave is called multiplex equipment and may be of the digital or analog type.

6.2 Radio should be used when the distance between the radio terminals is such that the annual costs of the cable with span line repeaters are equal to or greater than the annual costs of radio. An example would be where the terrain or weather makes installation and maintenance costs of physical plant exorbitant. This could make radio feasible over relatively short distances.

6.3 Typical radio path lengths range from 10 to 40 miles with the average being about 25 miles. Intervening terrain and precipitation are the contributing factors that set the maximum length. (Precipitation is not a factor for operating frequencies below 11,000 MHz.) Line-of sight transmission is required for microwave, whereas it may not be necessary for the single channel subscriber radio link. Antenna supporting structures (towers) will vary depending on path length and terrain elevations at the terminal sites and along the path. REA TE&CM 931 "Microwave Propagation and Path Surveys" covers design criteria.

TRANSMISSION LIMITS

PCM SUBSCRIBER CARRIER/CONCENTRATOR



STATION CARRIER

GROUPED OR DISTRIBUTED TYPE

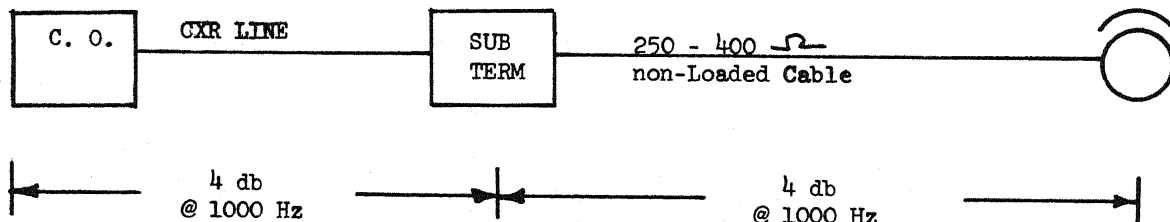
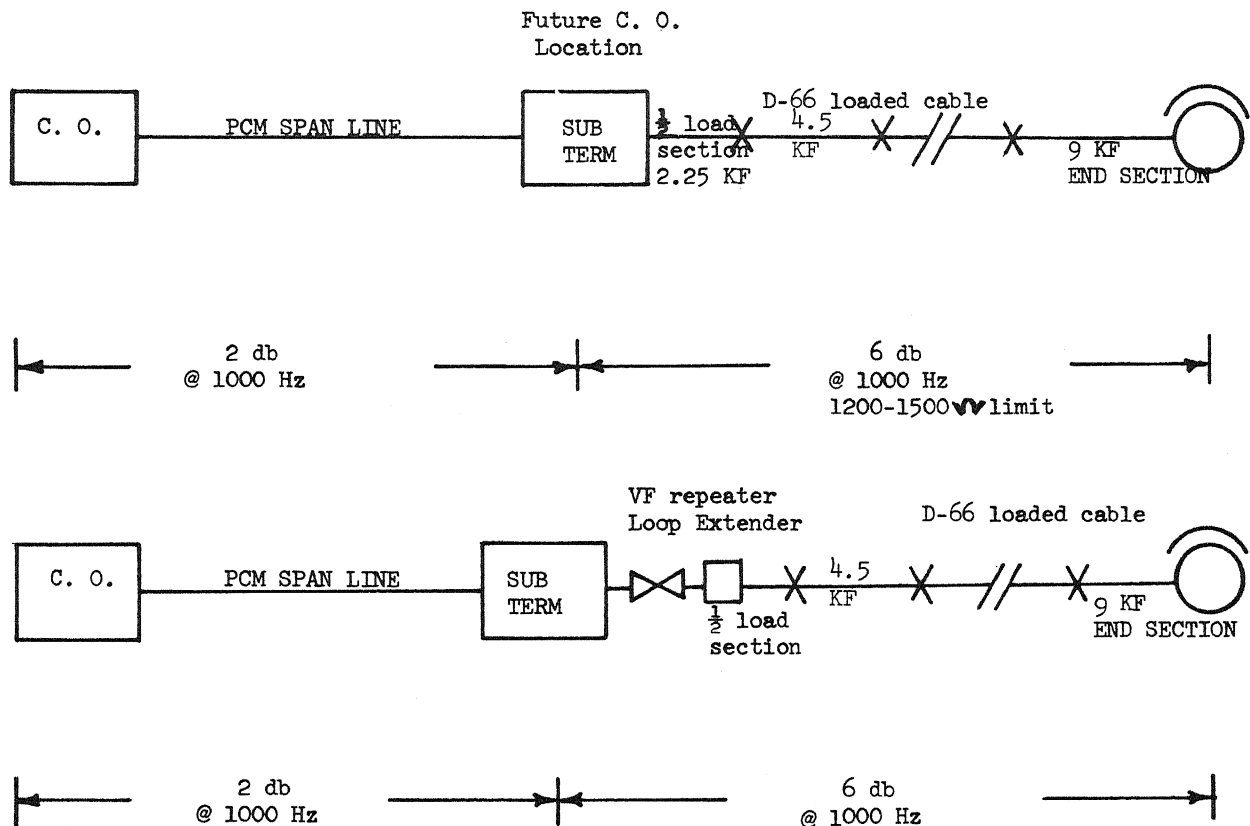


EXHIBIT I

TRANSMISSION LIMITS

SPECIAL APPLICATIONS

PCM SUBSCRIBER CARRIER/CONCENTRATOR



WHERE A NEW CENTRAL OFFICE MAY BE ESTABLISHED OR IF VF REPEATERS ARE REQUIRED AT SUBSCRIBER TERMINAL, PLACE EQUIPMENT AT $\frac{1}{2}$ load point.

EXHIBIT II

Appendix A

Examples Showing Development of Carrier Channel Costs

1.0 To compare electronic equipment versus physical cable costs and determine the optimum prove-in distances, some form of cost averaging must be developed. This appendix serves as an example of how to separate these costs into a useful form that can be periodically updated. It must be emphasized that these costs serve only as an example of a portion of the equipment available today. Costs should be developed on many types of equipment, and should be periodically updated.

1.1 One purpose of these comparative costs is to demonstrate the following:

- a. Distributed station carrier costs are rather uniform (for a given type). Since there is very little shared equipment, the costs are affected very little by subscriber density or number of systems along a route.
- b. Grouped station carrier costs are only moderately affected by subscriber density and number of systems along a route. There is some shared equipment that affect the per channel cost such as subscriber housings.
- c. PCM subscriber carrier costs are very much affected by subscriber density and number of systems along a route.
- d. Naturally, all per channel costs are affected by system length. This is reflected in the per channel share of repeater costs.

1.2 In the development of these costs, the following assumptions are made. The carrier facilities are to be new 24-gauge filled screen cable. Each system is fully equipped with channels. Spare parts are calculated at 5 percent of basic electronic equipment costs. The central office terminal installation costs include hardware, wiring and labor, and average \$11 per channel, regardless of equipment type. To establish ac power at a location, a charge of \$175 is used. A more specific breakdown of the assignment of costs is shown in the following paragraphs.

1.3 Because of significant differences between carrier applications and physical applications, a comparison between physical and carrier plan is best done by comparing 80 percent filled physical circuit with 100 percent filled carrier channels. It is pointed out that in Phase I, the number of circuits required are determined using fill factors corresponding to low, medium, or high growth expectations, whether physical or carrier derived feeders are involved. In Phase II, the correct number carrier pairs are specified to provide carrier systems to meet the required circuit requirements. During application engineering of carrier systems, fill the systems

s close to 100 percent capacity as possible. Carrier pairs are available for adding more carrier systems if needed. Thus the costs derived here are based on full carrier systems.

.4 Exhibit A-1 shows the installed per channel cost with full systems where there are one and four systems on a route. The most significant savings from sharing equipment is reflected in PCM carrier. Most of this quantity savings is because of the shared repeater housing. Also note that the per channel cost of remote power for distributed station carrier is reduced significantly if it can be shared with several systems.

.41 The per channel costs reflect major reinforcement considerations. If carrier is applied to existing facilities, telephone ringer changeout (estimated at \$13 per channel) and loading coil removal (estimated at \$3 to \$8 per channel) should be considered. One-party carrier channels often require straight line ringers.

.5 Distributed Station Carrier

a. Channel costs include:

Common = CO shelf, common equipment and termination unit

Channels = CO channel cards and subscriber channels

b. Subscriber installation includes labor and some costs for pedestal housing changeout.

c. Repeater installation costs include labor and either a shared housing cost or some pedestal changeout costs.

d. If the system length exceeds 3000 ohms, remote power, installation, and ac power costs are included.

.51 Grouped Subscriber Carrier

a. Channel costs include:

Common = CO shelf, CO common equipment, subscriber common equipment and subscriber housing.

Channels = CO and subscriber channel cards

b. Subscriber installation is primarily labor to install the housing.

c. Repeater installation cost includes labor and either a shared housing cost or some pedestal changeout costs.

d. If the system length exceeds 3000 ohms, remote booster power and installation costs are included and ac power costs are included.

1.52 PCM Subscriber Carrier

a. Channel costs include:

Common = CO common equipment, subscriber common equipment, office and subscriber repeaters, subscriber batteries, ringing and power equipment, and subscriber housing

Channels = CO and subscriber channel cards

b. Subscriber installation costs include labor for the housing installation and the cost to establish ac power.

c. Repeater installation is calculated at 10 percent of the housing and repeater cost.

2.0 Development of Equipment Costs

2.1 Distributed Station Carrier (7 Channels)

Common	\$ 222
Channels (\$412 x 7)	<u>2,884</u>
System Cost =	\$3,106

Channel Equipment Cost = $\$3,106 \div 7 = \444

There are no shared costs except in the changeout of pedestal housings for repeaters and subscriber terminals. These are included as a part of the installation costs.

Channel	\$444
Spare Parts (5%)	22
CO Installation	11
Subscriber Installation	<u>23</u>
Installed Per Channel Cost =	\$500

Repeater	\$320
Spare Parts (5%)	16
Installation	<u>17</u>
Installed Repeater Cost =	\$353

Per Channel Share of Repeater = $\$353 \div 7 = \50 per channel

Installed Per Channel Costs (7 Ch. Dist.)

Repeaters	Costs	Per Channel Cost
0	\$500 + 0	\$500
1	\$500 + 50	\$550
2	\$500 + 100	\$600
3	\$500 + 150	\$650
4*	\$500 + 200	\$700*
5*	\$500 + 250	\$750*

*If the system length exceeds 3000 ohms, remote power is required along the cable route. The installed cost for the first system is \$2,009, including \$1,819 for equipment, \$175 to establish ac power and \$15 for installation.

Remote Power Costs

Systems	Installed Cost	Per Channel Cost
1	\$2,009	\$287
2	2,014	144
3	2,019	96
4	2,180	78
5	2,185	62
6	2,190	52

2.2 Grouped Station Carrier (6 Channels)

	1 System	4 Systems	10 Systems
Common	\$ 496	\$1,424	\$ 2,595
Channels (\$270 x 6)	1,620	6,480	16,200
Totals	\$2,116	\$7,904	\$18,795
Per Channel Cost =	\$353	\$329	\$313
Channel	\$353	\$329	\$313
Spare Parts (5%)	18	16	16
CO Installation	14	14	14
Subscriber Installation	13	13	13
Installed Per Channel Cost =	\$398	\$372	\$356

Repeater	\$200
Spare Parts (5%)	10
Installation	38
<hr/>	
Installed Repeater Cost =	\$248

Per Channel Share of Repeater = $\$248 \div 6 = \41 per channel

Installed Per Channel Costs (6 Channels Grouped)

Repeaters	1 System	4 Systems	10 Systems
0	398	372	356
1	439	413	397
2	480	454	438
3	521	495	479
4	562*	536*	520*
5*	603*	577*	561*

*If the system length exceeds 3000 ohms, remote power is also required along the cable route. The installed cost of the remote power for the first system is \$2,000, including \$1,810 for equipment, \$175 to establish ac power and \$15 for installation.

Remote Power Costs

Systems	Installed Cost	Per Channel Cost
1	\$2,009	\$335
2	2,014	168
3	2,019	112
4	2,180	91
5	2,185	73
6	2,190	61

2.3 PCM Subscriber Carrier (24 Channels)

	<u>1 System</u>	<u>4 Systems</u>
Common	\$5,520	\$17,640
Channels (\$160 x 24)	<u>3,840</u>	<u>15,360</u>
Totals =	\$9,360	\$33,000
Per Channel Cost =	\$390	\$344

	<u>1 System</u>	<u>4 Systems</u>
Channel	\$390	\$344
Spare Parts (5%)	20	17
CO Installation	11	11
Subscriber Installation	<u>22</u>	<u>16</u>
Installed Per Channel Cost	443	388

	<u>1 System</u>	<u>4 Systems</u>
Repeaters	\$120	\$ 480
Housing	410	410
Spare Parts (5%)	27	45
Installation	<u>53</u>	<u>89</u>
Totals =	\$610	\$1,024
Per Channel Share of Repeater =	\$25	\$11

Installed Per Channel Costs (24 Ch. PCM)

Repeaters	1 System		4 Systems	
	Costs	Per Channel Cost	Costs	Per Channel Cost
0	443 + 0	\$443	388 + 0	\$388
4	443 + 100	543	388 + 44	432
8	443 + 200	643	388 + 88	476
12	443 + 300	743	388 + 132	520
16	443 + 400	843	388 + 176	564
20	443 + 500	943	388 + 220	608

Exhibit A-1

Cost Comparison of Installed Subscriber Carrier: Full Systems

Per channel cost based on full systems on 24 gauge filled screen cable D-66 loaded.

Sub. Term. At	Ohms	Rep.	Dist. 7 Ch.		Grouped 6 Ch.		Rep.	PCM 24 Ch.	
			1 Sys.	4 Sys.	1 Sys.	4 Sys.		1 Sys.	4 Sys.
LP 1	115	0	500	500	398	372	0	443	388
2	346	0	500	500	398	372	1	468	399
3	577	0	500	500	398	372	2	493	410
4	808	0	500	500	398	372	2	493	410
5	1039	1	550	550	439	413	3	518	421
6	1270	1	550	550	439	413	4	543	432
7	1501	1	550	550	439	413	5	568	443
8	1732	2	600	600	480	454	5	568	443
9	1963	2	600	600	480	454	6	593	454
10	2194	2	600	600	480	454	7	618	465
11	2425	2	600	600	480	454	8	643	476
12	2656	3	650	650	521	495	8	643	476
13	2887	3	650	650	521	495	9	668	487
14	3118	3	937*	728*	856*	586*	10	693	498
15	3349	4	987*	778*	897*	627*	11	718	509
16	3580	4	987*	778*	897*	627*	11	718	509
17	3811	4	987*	778*	897*	627*	12	743	520
18	4042	4	987*	778*	897*	627*	13	768	531

Note: PCM repeaters - 20 dB from office and spaced at 31 dB thereafter.
Station carrier repeaters at loading point 4, 7.5, 11, 14.5 and 18.

*Exceeds 3000 ohms; cost of field power included.